Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/GB05/000120

International filing date: 14 January 2005 (14.01.2005)

Document type: Certified copy of priority document

Document details:
Country/Office: GB
Number: 0400808.2
Filing date: 14 January 2004 (14.01.2004)

Date of receipt at the International Bureau: 17 February 2005 (17.02.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

PCT/GB 2005 / 0 0 0 1 2 0

31 JANUARY 2005

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 20 January 2005

Patents Form 1/77

THE PATENT OFFICE
SW
14 JAN 2004
LONDON

The Patent Office

Patents Act 1977
(Rule 16)

1/77

15JAN04 E865417-1 D02882
P01/7700 0.00-0400808.2 NONE

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Concept House
Cardiff Road
Newport
South Wales NP10 8QQ

1.	Your reference	**AWP/P70346GB00**
2.	Patent application number *(The Patent Office will fill in this part)*	14 JAN 2004 0400808.2
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	**LOTUS CARS LIMITED HETHEL NORWICH NORFOLK NR14 8EZ UNITED KINGDOM**
	Patents ADP number *(if you know it)*	573 9743001
	If the applicant is a corporate body, give the country/state of its incorporation	**UNITED KINGDOM**
4.	Title of the invention	**A TURBOCHARGED INTERNAL COMBUSTION ENGINE**
5.	Name of your agent *(if you have one)*	**BOULT WADE TENNANT**
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	**VERULAM GARDENS 70 GRAY'S INN ROAD LONDON WC1X 8BT**
	Patents ADP number *(if you know it)*	**42001**
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority application number (if you know it) / Date of filing *(day/month/year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application / Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))*	**YES**

9.	Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document	
	Continuation sheets of this form	
	Description	9
	Claim(s)	4
	Abstract	-
	Drawing(s)	2 + 2
10.	If you are also filing any of the following, state how many against each item.	
	Priority documents	-
	Translations of priority documents	-
	Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
	Request for preliminary examination and search *(Patents Form 9/77)*	-
	Request for substantive examination *(Patents Form 10/77)*	-
	Any other documents *(Please specify)*	
11	I/We request the grant of a patent on the basis of this application. Signature	Date 14 January 2004
12.	Name and daytime telephone number of person to contact in the United Kingdom	**MR.A.W. PLUCKROSE 020 7430 7500**

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents ct 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 01645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

A TURBOCHARGED INTERNAL COMBUSTION ENGINE

The present invention relates to a turbocharged internal combustion engine.

Turbocharged internal combustion engines are well known. However, it has always been a problem to control effectively the speed of rotation of turbochargers in engines in order to control the boost applied to the intake air. Wastegates have been necessary or complicated valving arrangements. Furthermore, now that it is necessary to meet strict emissions regulations for all engines, the use of high pressure turbochargers is problematic because the restrictions on flow imposed by such turbochargers and the cooling of exhaust gases thereby tends to lead to unacceptable delays in catalytic converter light off. Traditionally, in engines with two-stage turbocharging it has been a problem elegantly to control the boost provided by each turbocharger in relation to the other.

The present invention provides a turbocharged internal combustion engine comprising:

a variable volume combustion chamber;

inlet valves means controlling flow of air into the combustion chamber;

fuel delivery means for delivering fuel into the air to be mixed therewith;

exhaust valve means for controlling flow of the combusted gases from the combustion chamber;

compressor means for compressing the air prior to admission of the air into the combustion chamber;

actuator means opening and closing the exhaust valve means; and

an electronic controller which controls operation of the actuator means to thereby control opening and closing of the exhaust valve means; wherein:

the exhaust valve means comprises at least a first exhaust valve connected to a first exhaust duct and at least a second exhaust valve connected to a second exhaust duct, separate and independent from the first exhaust duct;

the compressor means comprises a first turbocharger and the first exhaust duct is connected to the first turbocharger so that exhaust gases passing through the first exhaust duct drive the first turbocharger to rotate;

the second exhaust duct bypasses the first turbocharger and the combusted gases flowing through the second exhaust duct are exhausted without passing through the first turbocharger; and

the electronic controller by controlling operation of the actuating means and thereby the opening and closing of the first and second exhaust valves is operable to control what proportion of the combusted gases leaving the cylinder flow through each of the first and second exhaust ducts.

By the use of actuators controlled by an electronic controller the operation of the exhaust valves can be controlled in such a way that the controller can control the volume and rate of flow of combusted gases through the first turbocharger and thereby control operation of the first turbocharger in an elegant way.

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows schematically a first embodiment of an internal combustion engine according to the present invention, the engine having a single stage charging system; and

Figure 2 shows a second embodiment of a turbocharged internal combustion engine according to the present invention, the engine having a two-stage charging system.

In Figure 1 there can be seen a four-cylinder engine having four cylinders 10, 11, 12 and 13. Each cylinder has an inlet valve "i" and two exhaust valves "a" and "b". The exhaust valves "a" and "b" at least are each operated by a hydraulic actuator connected to the valve. Each hydraulic actuator will be controlled by an electronic controller (not shown) which will typically be part of the engine management of the system. Each exhaust valve "a" will be opened and closed independently of the exhaust valve "b" in the same cylinder.

Combusted gases flowing from the cylinders 10, 11, 12 and 13 flow through the exhaust valves "a" to a first exhaust duct 14. This exhaust duct 14 relays the combusted gases to the turbine stage 15a of a turbocharger 15.

The exhaust valves "b" are all connected to a second exhaust duct 16 through which combusted gases can flow from the cylinders 10, 11, 12 and 13 through the exhaust valves "b" to a starter catalytic converter 17.

The combusted gases expanded in the turbine 15a are output from the turbocharger 15 via an exhaust duct 18, which is joined to the exhaust duct 16 at a joint 19. At the joint 19 the combusted gases flowing from the turbocharger 15 combine with the combusted gases flowing through the exhaust duct 16 and then the combined flow passes through a second catalytic converter 21 and then to atmosphere.

Fresh charge air is drawn into the compressor section 15b of the turbocharger 15 and is then relayed via an intake passage 19 to the intake valves "i" of the cylinders 10, 11, 12 and 13, the charge air passing through an intercooler 20 on its way to the cylinders.

The electronic controller can use its control of the actuators to control the opening and closing of the exhaust valves "a" and "b" to control what proportion of the total combusted gases flowing from each cylinder flow to the exhaust duct 14 and what proportion of the combusted gases flow through the exhaust duct 16. In this way the controller can control operation of the turbocharger 15. When greater boost is required then a greater proportion of the total combusted gases expelled from the cylinders 10, 11 12 and 13 is fed through the turbocharger 15 and vice versa. On start-up of the engine the majority of the combusted gases expelled from the cylinders 10, 11, 12 and 13 (if not the totality of the combusted gases expelled) will pass through the exhaust duct 16 in order to ensure an early light off of the starter catalytic converter 17 and therefore reduce the emissions on engine start-up.

In Figure 2 a second variant of engine according to the present invention is shown. This engine has four cylinders 100, 101, 102 and 103, each cylinder having an intake valve "i", an exhaust valve "a" and an exhaust valve "b". The exhaust valves "a" and "b" at least are operated by hydraulic actuators under the control of an electronic controller (not shown). Each exhaust valve "a" can be operated independently from the exhaust valve "b" in the same cylinder.

The exhaust valves "a" of the cylinders 100, 101, 102 and 103 are all connected to a first exhaust duct 104 which leads the combusted gases to the turbine part 105a of a high pressure turbocharger 105. The exhaust valves "b" of the cylinders 100, 101, 102 and 103 are all connected to an exhaust duct 106 through which the combusted gases flow to a turbine section 107a of a low pressure turbocharger 107, bypassing the high pressure turbocharger 105.

Expanded combusted gases exiting the turbine part 105a of the turbocharger 105 flow via an exhaust duct 108 to a joint 109 where the expanded combusted gases are fed into the flow of combusted gases passing along the exhaust duct 106. It is the combined flow of the combusted gases passing directly from the exhaust valves "b" and the combusted gases exiting the turbocharger 105 which are then fed to the turbine 107a of the low pressure turbocharger 107.

The combusted gases exiting the turbine 107a of the turbocharger 107 pass through an exhaust passage 110 to atmosphere via a catalytic converter 111.

Charge air drawn into the compressor part 107b of the turbocharger 107 is expelled through an intake duct 112 to be passed through an intercooler 113. The compressed air, once cooled in the intercooler 113 can then pass either through the compressor part 105b of the high pressure turbocharger 105 or can pass along a bypass passage 114, bypassing the turbocharger 105 completely.

The compressed air supplied to the turbocharger 105 will be supplied at a first pressure and will then be pressurised to a higher second pressure by the turbocharger 105. The pressurised air leaving the compressor 105a passes through a duct 115 to be recombined with air flowing through the bypass passage 114. The combined air flow then passes through an intercooler 116 and an intake duct 117 to the intake valves "i".

A bypass valve 118 is provided in the bypass passage 114. The bypass valve 118 is be controlled by the electronic controller. Operation of the bypass valve 118 will enable the electronic controller to control how much of the intake air passes through the high pressure turbocharger 105.

The electronic controller controls opening and closing of the exhaust valves "a" and "b" (through which control of the actuators connected to the exhaust valves) in order to control what proportion of the total flow of combusted gases from the cylinders 100, 101, 102 and 103 flow through the exhaust duct 104 and what proportion of the combusted gases flow through the exhaust duct 106. In this way, the

electronic controller can control operation of the turbochargers 105 and 107.

In certain circumstances it will be preferable that all or at least the majority of the flow of combusted gases bypasses the turbocharger 105 completely. In this circumstance, the exhaust valves "a" are kept totally (or mostly) closed and the exhaust valves "b" are opened and closed on their own in each cycle. In this circumstance the electronic controller will also open fully the bypass valve 118 so that charge air does not pass through the turbocharger 105. For instance it is desirable on start-up of the engine to bypass the turbocharger 105 completely. Since the turbocharger 105 is a high pressure turbocharger, it will provide a large restriction on the flow of combusted gases from the cylinders. This restriction and the resultant cooling of the combusted gases will increase the time to light off of the catalyst 111. On the other hand, the low pressure turbocharger 107 will place far less a restriction on the combusted gases and therefore it is preferable that at start up conditions the combusted gases flow only through the turbocharger 107.

The system described in Figure 2 removes the need for a waste gate which is, by its very nature, wasteful. In the Figure 2 arrangement all the combusted gases pass through the turbine 107.

The level of boost provided to the intake air supplied to the intake valves "i" can easily be controlled by electronic controller by varying the valve timing of the exhaust valves "a" and "b" in order to control the gas flow

through the exhaust duct 104. Also, the controller can control boost by controlling the bypass valve 118.

The low pressure turbocharger 107 will be a turbocharger with a large turbine, giving a resistance to the flow of combusted gases much less than the high pressure turbocharger 105, which has a smaller turbine. However, the larger turbine size of the low pressure turbocharger 107 can lead to throttle response problems which are particularly problematic in the use of the engine in an automobile. This problem is ameliorated by the present invention by the electronic controller recognising times of acceleration of the engine and in such times diverting the majority of the flow of combusted gases to the high pressure turbocharger 105 which will react quickly when the throttle of the engine is open. Obviously, the bypass valve 118 is closed in such circumstances, in order that the intake air received by the inlet valves "i" is boosted to its maximum.

At high engine speeds the high pressure turbocharger 105 could provide an excess of boost if not suitably controlled by the electronic controller controlling the flow of combusted gases through the exhaust duct 104 and the flow of intake air through the bypass passage 114. Typically at full loads and high engine speeds in steady state conditions the high pressure turbocharger 105 will be in the main bypassed so that the majority of intake air will flow in the bypass passage 114 and the majority of combusted gas flow will be through the exhaust duct 106.

The engines described above are four-cylinder reciprocating piston engines, which could be operated either

with spark ignition or with compression ignition. However, the invention is equally applicable to reciprocating piston engines with any number of cylinders and furthermore is applicable to internal combustion engines other than reciprocating piston engines (e.g. rotary engines).

The exhaust valves "a" and "b" described above will be poppet valves operated by hydraulic actuators. However, the poppet valves could be operated by any other suitable form of actuator, e.g. electromagnetic actuators. Indeed the poppet valves could be replaced by sleeve valves or any other suitable valving arrangement controllable by actuator.

The inlet valves "i" described above would preferably themselves be controlled by actuators under the control of the electronic controller but this is not necessary and any form of operation of the valves could be used, e.g. conventional cam and tappet operation.

In the embodiments described above only one inlet valve "i" is provided per cylinder, but preferably two inlet valves "i" would be provided per cylinder.

CLAIMS

1. A turbocharged internal combustion engine comprising:

a variable volume combustion chamber;

inlet valve means controlling flow of air into the combustion chamber;

fuel delivery means for delivering fuel into the air to be mixed therewith;

exhaust valve means for controlling flow of combusted gases from the combustion chamber;

compressor means for compressing the air prior to admission of the air into the combustion chamber;

actuator means for opening and closing the exhaust valve means; and

an electronic controller which controls operation of the actuator means to thereby control opening and closing of the exhaust valve means, wherein:

the exhaust valve means comprises at least a first exhaust valve connected to a first exhaust duct and at least a second exhaust valve connected to a second exhaust duct separate and independent from the first exhaust duct;

the compressor means comprises a first turbocharger and the first exhaust duct is connected to the first turbocharger so that exhaust gases passing through the first exhaust duct drive the first turbocharger to rotate;

the second exhaust duct bypasses the first turbocharger and the combusted gases flowing through the second exhaust duct are exhausted without passing through the first turbocharger; and

the electronic controller by controlling operation of the actuator means and thereby the opening and closing of the first and second exhaust valves is operable to control

what proportion of the combusted gases leaving the cylinder flow through each of the first and second exhaust ducts.

2. A turbocharged internal combustion engine as claimed in claim 1 wherein combusted gases leaving the first turbocharger after expansion in a turbine of the first turbocharger are combined at a junction with the combusted gases flowing in the second exhaust duct and then the combined flow of combusted gases flow through a first catalytic converter and then to atmosphere.

3. A turbocharged internal combustion engine as claimed in claim 2 comprising additionally a second catalytic converter provided in the second exhaust duct upstream of the junction at which combusted gases in the second exhaust duct are combined with combusted gases leaving the first turbocharger.

4. A turbocharged internal combustion engine as claimed in claim 3 wherein on starting of the engine the controller controls opening and closing of the first and second exhaust valves so that all or at least a majority of the combusted gases leaving the cylinder pass through the second exhaust duct and therefore the second catalytic converter.

5. A turbocharged internal combustion engine as claimed in any one of claims 1 to 4 comprising additionally an intercooler for cooling compressed air flowing from the turbocharger to the cylinder.

6. A turbocharged internal combustion engine as claimed in claim 1 wherein:

the compressor means comprises additionally a second turbocharger;

the first turbocharger is a high pressure turbocharger which can receive compressed air at a first pressure from the second turbocharger, which is a low pressure turbocharger, and the first turbocharger compresses the air to a second higher pressure; and

combusted gases leaving the first turbocharger after expansion in a turbine thereof are combined with the combusted gases flowing in the second exhaust duct and then the combined flow of combusted gases drive the second turbocharger to rotate.

7. A turbocharged internal combustion engine as claimed in claim 6 wherein combusted gases leaving the second turbocharger flow through a catalytic converter and then to atmosphere.

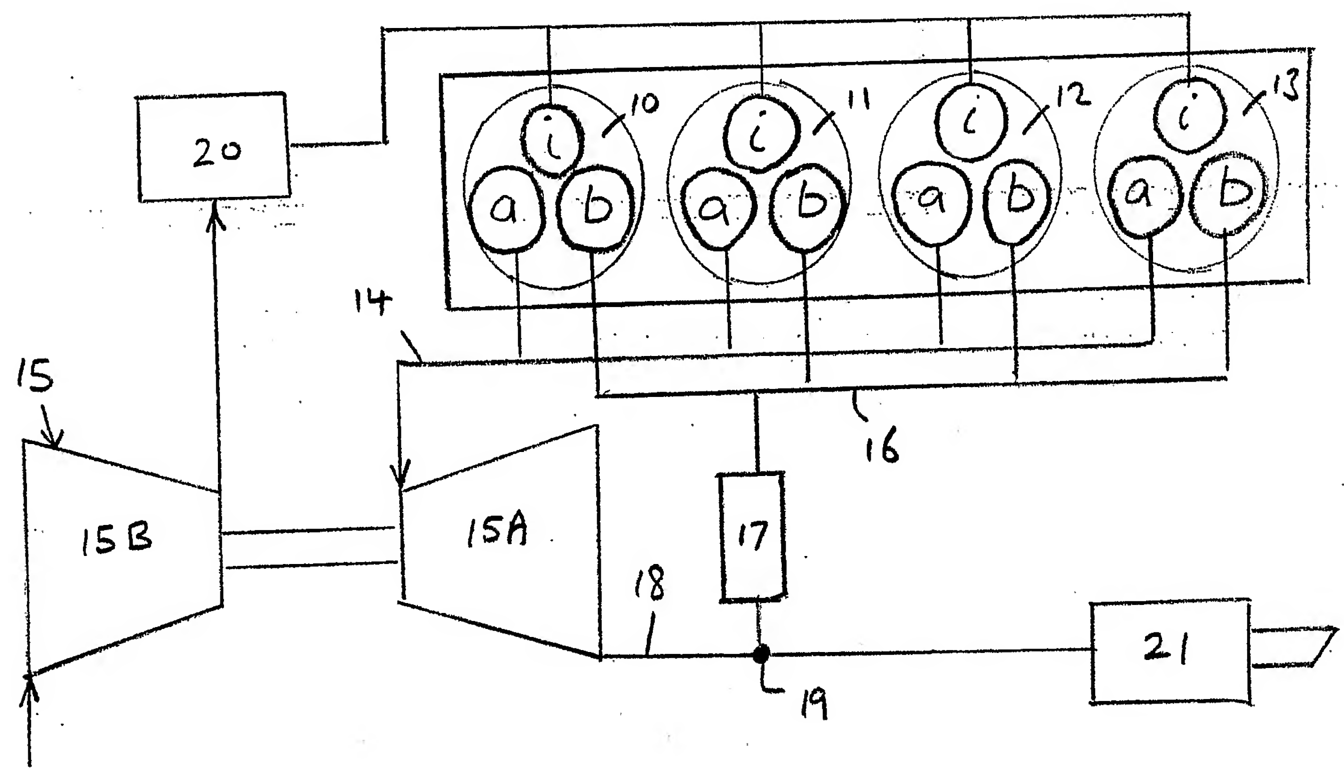
8. A turbocharged internal combustion engine as claimed in claim 6 or claim 7 comprising additionally a first intercooler through which air compressed in the second low pressure turbocharger passes before reaching the first high pressure turbocharger.

9. A turbocharged internal combustion engine as claimed in any one of claims 6 to 8 comprising additionally an intake air bypass passage through which air compressed by the second turbocharger can flow to the intake valve means bypassing the first turbocharger and bypass valve means controlling flow of the compressed air through the bypass passage.

10. A turbocharged internal combustion engine substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

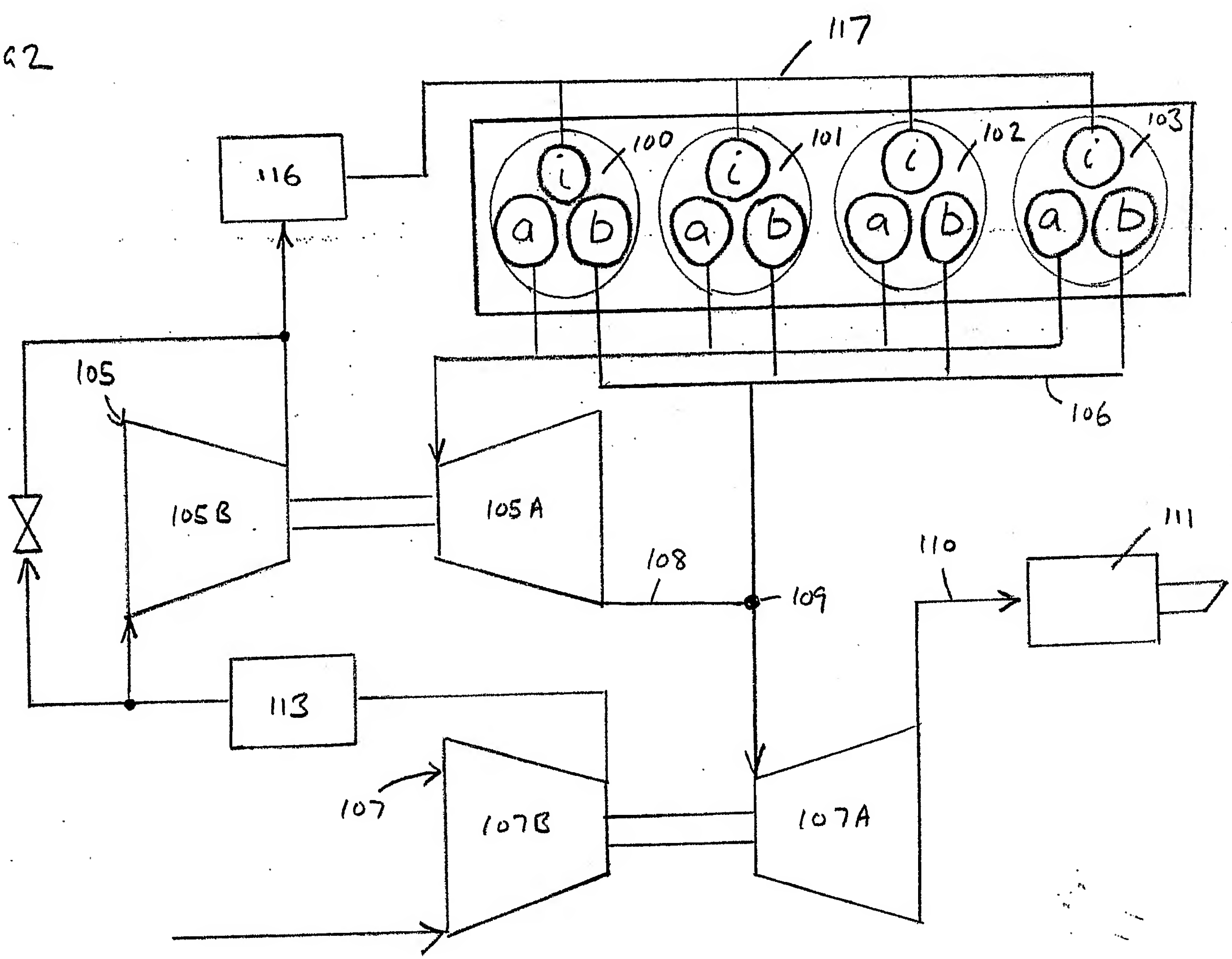
#516951 v1 - LOTUS BWT 169 spec -Turbocharger

FIG 1



1/2

FIG 2



117
116
100
101
102
103
i
a
b
105
105B
105A
106
108
109
110
111
113
107
107B
107A